

What Is Claimed Is:

- 1 1. A data recovery circuit, comprising:
 - 2 a clock generator for generating a first group of
 - 3 sampling clock pulses and a second group of sampling
 - 4 clock pulses for sampling an incoming data stream, each
 - 5 sampling edge of said first group of sampling clock
 - 6 pulses and each sampling edge of said second group of
 - 7 sampling clock pulses being arranged alternatively and
 - 8 being separated from each other for an interval equal
 - 9 to half the period of said incoming data stream, said
 - 10 clock generator being controlled in response to a phase
 - 11 control signal to adjust phases of said first group of
 - 12 sampling clock pulses and said second group of sampling
 - 13 clock pulses;
 - 14 a data and phase sampling circuit for receiving said
 - 15 incoming data stream, said first group of sampling clock
 - 16 pulses and said second group of sampling clock pulses,
 - 17 said data and phase sampling circuit taking samples of
 - 18 said incoming data stream in accordance with said first
 - 19 group of sampling clock pulses to produce a first sampled
 - 20 data stream while taking samples of said incoming data
 - 21 stream in accordance with said second group of sampling
 - 22 clock pulses to produce a second sampled data stream;
 - 23 and
 - 24 a phase detection and correction circuit coupled to
 - 25 said data and phase sampling circuit, for determining
 - 26 resemblances of each bit in said second sampled data
 - 27 stream to the corresponding two bits in said first
 - 28 sampled data stream, the associated sampling edge of said
 - 29 bit in said second sampled data stream being adjacent
 - 30 to the associated sampling edges of said two bits in said
 - 31 first sampled data stream, said phase detection and

32 correction circuit producing said phase control signal
33 on the basis of the resemblance determination result.

1 2. The data recovery circuit of claim 1, wherein said first
2 sampled data stream is used as a data recovery output.

1 3. The data recovery circuit of claim 1, wherein said first
2 group of sampling clock pulses and said second group of
3 sampling clock pulses have the same frequency, which is
4 equal to half the frequency of said incoming data stream.

1 4. The data recovery circuit of claim 3, wherein said first
2 group of sampling clock pulses includes a first clock
3 signal and said second group of sampling clock pulses
4 includes a second clock signal, said first clock signal
5 and said second clock signal being 90 degrees out of phase
6 with each other, and both rising edges and falling edges
7 of said first clock signal and said second clock signal
8 being used as said sampling edges.

1 5. The data recovery circuit of claim 3, wherein said first
2 group of sampling clock pulses includes a first clock
3 signal and a third clock signal and said second group
4 of sampling clock includes a second clock signal and a
5 forth clock signal, said first clock signal and said
6 second clock signal being 90 degrees out of phase with
7 each other, said first clock signal and said third clock
8 signal being 180 degrees out of phase with each other,
9 and said second clock signal and said forth clock signal
10 being 180 degrees out of phase with each other.

1 6. The data recovery circuit of claim 5, wherein rising edges
2 of said first to said forth clock signals are used as
3 said sampling edges.

1 7. The data recovery circuit of claim 5, wherein falling
2 edges of said first to said forth clock signals are used
3 as said sampling edges.

1 8. The data recovery circuit of claim 1, wherein said first
2 group of sampling clock pulses and said second group of
3 sampling clock pulses have the same frequency, which is
4 equal to the frequency of said incoming data stream.

1 9. The data recovery circuit of claim 1, further comprising
2 a demultiplexer coupled between said data and phase
3 sampling circuit and said phase detection and correction
4 circuit, for converting said first sampled data stream
5 and said second sampled data stream from serial data to
6 parallel data.

1 10. The data recovery circuit of claim 1, wherein said phase
2 detection and correction circuit comprises:
3 an early/late determination circuit for receiving said
4 first sampled data stream and said second sampled data
5 stream and determining resemblances of each bit in said
6 second sampled data stream to the corresponding two bits
7 in said first sampled data stream, the associated
8 sampling edge of said bit in said second sampled data
9 stream being adjacent to the associated sampling edges
10 of said two bits in said first sampled data stream, said
11 early/late determination circuit selectively producing
12 an early signal and a late signal;
13 an early/late summation circuit for receiving said
14 early signal and said late signal and producing an
15 early/late summation signal on the basis of a summation
16 result of said early signal and said late signal; and

17 a low pass filter for receiving said early/late
18 summation signal and producing said phase control
19 signal.

1 11.The data recovery circuit of claim 10, wherein said
2 early/late determination circuit comprises:

3 a resemblance detection circuit for detecting whether
4 or not said corresponding two bits in said first sampled
5 data stream are the same, detecting whether said bit in
6 said second sampled data stream is equal to the former
7 or the latter of said corresponding two bits if said two
8 bits are not the same, and accordingly producing a
9 resemblance signal of said bit; and

10 an early/late decision circuit for receiving the
11 resemblance signals of a predetermined number of bits,
12 comparing the number of times that said bit is equal to
13 the former of said corresponding two bits with the number
14 of times that said bit is equal to the latter of said
15 corresponding two bits, and selectively producing said
16 early signal or said late signal.

1 12.The data recovery circuit of claim 10, wherein said
2 early/late summation circuit performs an addition
3 operation to add one to an accumulative amount responsive
4 to receiving said early signal while performs an
5 subtraction operation to subtract one from the
6 accumulative amount responsive to receiving said late
7 signal and outputs the accumulative amount as said
8 early/late summation signal, and wherein said low pass
9 filter produces said phase control signal on the basis
10 of the polarity of said early/late summation signal
11 obtained after a predetermined times of summation
12 operations by said early/late summation circuit.

1 13. A phase detection circuit for detecting phase conditions
2 of a first group of sampling clock pulses and a second
3 group of sampling clock pulses in a data recovery circuit,
4 said first group of sampling clock pulses being used for
5 sampling approximately a central portion of each data
6 bit in an incoming data stream to produce a first sampled
7 data stream while said second group of sampling clock
8 pulses being used for sampling approximately a
9 transition portion between every two data bits in said
10 incoming data stream to produce a second sampled data
11 stream, said phase detection circuit comprising:
12 an early/late determination circuit for receiving said
13 first sampled data stream and said second sampled data
14 stream, comprising:
15 a resemblance detection circuit including a
16 plurality of resemblance detecting units, each of said
17 plurality of resemblance detecting units being used for
18 detecting whether one of a plurality of bits in said
19 second sampled data stream is equal to the former or
20 the latter of the corresponding two bits in said first
21 sampled data stream and producing one of a plurality
22 of resemblance signals; and
23 an early/late decision circuit for receiving said
24 plurality of resemblance signals corresponding to said
25 plurality of bits, comparing the number of times that
26 one bit is equal to the former of the corresponding two
27 bits with the number of times that one bit is equal to
28 the latter of the corresponding two bits, and
29 selectively producing an early signal or a late signal.

1 14. The phase detection circuit of claim 13, further
2 comprising an early/late summation circuit for receiving

3 said early signal and said late signal and producing an
4 early/late summation signal on the basis of a summation
5 result of said early signal and said late signal.

1 15. The phase detection circuit of claim 14, wherein said
2 early/late summation circuit performs an addition
3 operation to add one to an accumulative amount responsive
4 to receiving said early signal while performs an
5 subtraction operation to subtract one from the
6 accumulative amount responsive to receiving said late
7 signal and outputs the accumulative amount as said
8 early/late summation signal.

1 16. A phase detection circuit for detecting phase conditions
2 of a first group of sampling clock pulses and a second
3 group of sampling clock pulses in a data recovery circuit,
4 said first group of sampling clock pulses being used for
5 sampling approximately a central portion of each data
6 bit in an incoming data stream to produce a first sampled
7 data stream while said second group of sampling clock
8 pulses being used for sampling approximately a
9 transition portion between every two data bits in said
10 incoming data stream to produce a second sampled data
11 stream, said phase detection circuit comprising:

12 an early/late determination circuit for receiving said
13 first sampled data stream and said second sampled data
14 stream, said early/late determination circuit
15 determining a resemblance of said first sampled data
16 stream and said second sampled data stream by detecting
17 whether one bit in said second sampled data stream is
18 equal to the former or the latter of the corresponding
19 two bits in said first sampled data stream and producing
20 an early signal or a late signal; and

21 an early/late summation circuit for receiving said
22 early signal and said late signal and producing an
23 early/late summation signal on the basis of a summation
24 result of said early signal and said late signal.

1 17.A data recovery circuit, comprising:
2 a clock generator for generating a first group of
3 sampling clock pulses and a second group of sampling
4 clock pulses for sampling an incoming data stream, each
5 sampling edge of said first group of sampling clock
6 pulses and each sampling edge of said second group of
7 sampling clock pulses being arranged alternatively and
8 being separated from each other for an interval equal
9 to half the period of said incoming data stream, said
10 clock generator being controlled in response to a phase
11 control signal to adjust phases of said first group of
12 sampling clock pulses and said second group of sampling
13 clock pulses;
14 a data and phase sampling circuit for receiving said
15 incoming data stream, said first group of sampling clock
16 pulses and said second group of sampling clock pulses,
17 said data and phase sampling circuit taking samples of
18 approximately a central portion of each data bit in said
19 incoming data stream in accordance with said first group
20 of sampling clock pulses to produce a first sampled data
21 stream while taking samples of approximately a
22 transition portion of every two bits in said incoming
23 data stream in accordance with said second group of
24 sampling clock pulses to produce a second sampled data
25 stream; and
26 a phase detection and correction circuit coupled to
27 said data and phase sampling circuit, for determine

28 resemblances of each bit in said second sampled data
29 stream to the corresponding two bits in said first
30 sampled data stream, said phase detection and correction
31 circuit defining an early condition for the phases of
32 said first group of sampling clock pulses and said second
33 group of sampling clock pulses if each bit in said second
34 sampled data stream resembles the former of the
35 corresponding two bits in said first sampled data stream
36 while defining a late condition for the phases of said
37 first group of sampling clock pulses and said second
38 group of sampling clock pulses if each bit in said second
39 sampled data stream resembles the latter of the
40 corresponding two bits in said first sampled data stream,
41 and producing said phase control signal on the basis of
42 said early condition or said late condition to adjust
43 the phases of said first group of sampling clock pulses
44 and said second group of sampling clock pulses by
45 shifting the phases backwards or forwards.

1 18. The data recovery circuit of claim 17, wherein said first
2 sampled data stream is used as a data recovery output.

1 19. The data recovery circuit of claim 17, wherein said first
2 group of sampling clock pulses and said second group of
3 sampling clock pulses have the same frequency, which is
4 equal to half the frequency of said incoming data stream.

1 20. The data recovery circuit of claim 19, wherein said first
2 group of sampling clock pulses includes a first clock
3 signal and said second group of sampling clock pulses
4 includes a second clock signal, said first clock signal
5 and said second clock signal being 90 degrees out of phase
6 with each other, and both rising edges and falling edges

7 of said first clock signal and said second clock signal
8 being used as said sampling edges.

1 21. The data recovery circuit of claim 19, wherein said first
2 group of sampling clock pulses includes a first clock
3 signal and a third clock signal and said second group
4 of sampling clock includes a second clock signal and a
5 forth clock signal, said first clock signal and said
6 second clock signal being 90 degrees out of phase with
7 each other, said first clock signal and said third clock
8 signal being 180 degrees out of phase with each other,
9 and said second clock signal and said forth clock signal
10 being 180 degrees out of phase with each other.

1 22. The data recovery circuit of claim 21, wherein rising
2 edges of said first to said forth clock signals are used
3 as said sampling edges.

1 23. The data recovery circuit of claim 21, wherein falling
2 edges of said first to said forth clock signals are used
3 as said sampling edges.

1 24. The data recovery circuit of claim 17, wherein said first
2 group of sampling clock pulses and said second group of
3 sampling clock pulses have the same frequency, which is
4 equal to the frequency of said incoming data stream.

1 25. The data recovery circuit of claim 17, further
2 comprising a demultiplexer coupled between said data and
3 phase sampling circuit and said phase detection and
4 correction circuit, for converting said first sampled
5 data stream and said second sampled data stream from
6 serial data to parallel data.

1 26. The data recovery circuit of claim 17, wherein said phase
2 detection and correction circuit comprises:
3 an early/late determination circuit for receiving said
4 first sampled data stream and said second sampled data
5 stream, determining whether each bit in said second
6 sampled data stream resembles the former or the latter
7 of the corresponding two bits in said first sampled data
8 stream, and selectively producing an early signal or a
9 late signal;
10 an early/late summation circuit for receiving said
11 early signal and said late signal and producing an
12 early/late summation signal on the basis of a summation
13 result of said early signal and said late signal; and
14 a low pass filter for receiving said early/late
15 summation signal and producing said phase control signal
16 to adjust the phases of said first group of sampling clock
17 pulses and said second group of sampling clock pulses
18 by shifting the phases backwards or forwards.

1 27. The data recovery circuit of claim 26, wherein said
2 early/late summation circuit performs an addition
3 operation to add one to an accumulative amount responsive
4 to receiving said early signal while performs an
5 subtraction operation to subtract one from the
6 accumulative amount responsive to receiving said late
7 signal and outputs the accumulative amount as said
8 early/late summation signal, and wherein said low pass
9 filter produces said phase control signal on the basis
10 of the polarity of said early/late summation signal
11 obtained after a predetermined times of summation
12 operations by said early/late summation circuit.

1 28. A method for detecting and correcting phase conditions

2 in a data recovery circuit, comprising:
3 sampling approximately a central portion of each data
4 bit in an incoming data stream in accordance with a first
5 group of sampling clock pulses to produce a first sampled
6 data stream while sampling approximately a transition
7 portion between every two data bits in said incoming data
8 stream in accordance with a second group of sampling
9 clock pulses to produce a second sampled data stream;
10 detecting whether each bit in said second sampled data
11 stream resembles the former or the latter of the
12 corresponding two bits in said first sampled data stream;
13 summarizing a plurality of detection results produced
14 in said detecting step to determine whether the phases
15 of said first group of sampling clock pulses and said
16 second group of sampling clock pulses are in an early
17 condition or in a late condition; and
18 adjusting the phases of said first group of sampling
19 clock pulses and said second group of sampling clock
20 pulses by shifting the phases backwards or forwards on
21 the basis of said early condition or said late condition.

1 29. A method for detecting and correcting phase conditions
2 in a data recovery circuit, comprising:
3 sampling approximately a central portion of each data
4 bit in an incoming data stream in accordance with a first
5 group of sampling clock pulses to produce a first sampled
6 data stream while sampling approximately a transition
7 portion between every two data bits in said incoming data
8 stream in accordance with a second group of sampling
9 clock pulses to produce a second sampled data stream;
10 combining a predetermined number of bits in said first
11 sampled data stream into a group to form a plurality of

12 first sampled data groups and combining a predetermined
13 number of bits in said second sampled data stream into
14 a group to form a plurality of second sampled data groups;
15 for each first sampled data group and the corresponding
16 second sampled data group, detecting whether each bit
17 in said second sampled data stream is equal to the former
18 or the latter of the corresponding two bits in the first
19 sampled data stream and respectively counting the number
20 of times that said bit is equal to the former of said
21 corresponding two bits and the number of times that said
22 bit is equal to the latter of said corresponding two bits;
23 for each first sampled data group and the corresponding
24 second sampled data group, producing an early signal if
25 the number of times that said bit is equal to the former
26 of said corresponding two bits is greater than the number
27 of times that said bit is equal to the latter of said
28 corresponding two bits, and producing a late signal if
29 the number of times that said bit is equal to the latter
30 of said corresponding two bits is greater than the number
31 of times that said bit is equal to the former of said
32 corresponding two bits;
33 summarizing a plurality of early signals and late
34 signals to determine whether the phases of said first
35 group of sampling clock pulses and said second group of
36 sampling clock pulses are in a early condition or in a
37 late condition; and
38 adjusting the phases of said first group of sampling
39 clock pulses and said second group of sampling clock
40 pulses by shifting the phases backwards or forwards on
41 the basis of said early condition or said late condition.

1 30. The method of claim 29, wherein said step of summarizing

2 a plurality of early signals and late signals is carried
3 out by performing an addition operation to add one to
4 an accumulative amount responsive to receiving said
5 early signal while performing an subtraction operation
6 to subtract one from the accumulative amount responsive
7 to receiving said late signal and outputting the
8 accumulative amount as an early/late summation signal.

1 31. The method of claim 30, wherein said step of adjusting
2 the phases of said first group of sampling clock pulses
3 and said second group of sampling clock pulses by shifting
4 the phases backwards or forwards is performed on the basis
5 of the polarity of said early/late summation signal.